Review of Ditch Scope and Effect Modeling and MnRAM Analysis used to Support the Village Meadows Comprehensive Wetland Management Plan

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Final Report

Sponsored by U.S. Army Engineer District, St. Paul

Contents

Preface

The work reported herein was performed by the U. S. Army Engineer Research and Development Center (ERDC) for the U. S. Army Engineer District, St. Paul. Funding was provided by St. Paul District.

This report was prepared by Mr. Chris Noble, Environmental Laboratory (EL) and Mr. Cary Talbot (who authored and reviewed the section on MODFLOW and XPSWMM), Coastal and Hydraulics Laboratory (CHL). Technical consultation and reviewed were provided by Dr. Ellis Clairain, Dr. Charles Klimas, Mr. R. Daniel Smith, and Dr. James Wakeley, EL, ERDC. This report was developed in response to questions from the St. Paul District regarding the interpretation of site characteristics and modeling data related to the Comprehensive Wetland Management Plan (CWMP) for the Village Meadows development proposed by the Rice Creek Watershed District (RCWD) and prepared by Emmons and Oliver Resources (EOR).

This work was performed under the general supervision of Dr. Morris Mauney, Jr., Chief, Wetlands and Coastal Ecology Branch, EL; Dr. David J. Tazik, Chief, Ecosystem Evaluation and Engineering Division, EL; and Dr. Elizabeth C. Fleming, Acting Director, EL.

COL James R. Rowan, EN, was Commander and Executive Director of ERDC. Dr. James R. Houston was Director.

1 Introduction

Purpose

The purpose of this report is to address several questions from the St. Paul District concerning the scope and effect of ditches and the wetland functional assessment for the Village Meadows development proposed in the Comprehensive Wetland Management Plan (CWMP). These questions were originally addressed by the author in a memo dated October 28, 2005. This report is a more formalized response and addresses additional comments from the St. Paul District. This report supersedes comments made in the October 2005 memo.

This report deals with two primary questions:

- Do the results of the scope and effect modeling provided by Rice Creek Watershed District (RCWD) correctly represent the impacts of ditches on the wet season water table, and

- Does the method of wetland assessment used by RCWD produce the same result that would have been attained by using the methods and analysis specified by the published MnRAM documentation.

Background and Summary (provided by the St. Paul District)

The St. Paul District requested that ERDC review The Village Meadows Comprehensive Wetland Management Plan (CWMP) (EOR 2003) and provide an independent review of the scope and effect of the modeling and wetland functional assessment methodologies performed by the RCWD and their consultants.

The CWMP was developed by the RCWD to address several issues, including increased development pressure in a rapidly urbanizing portion of their watershed. According to the RCWD, their intent was to balance natural area preservation and land development in a comprehensive manner rather than a piecemeal approach.

The CWMP encompasses an 1100-acre site located in the north metro area of the Twin Cities. At the time the CWMP was developed, about 690 acres of the site were wetlands. A network of public and private ditches is present on the site.

In developing the CWMP, the RCWD used the theoretical **Post-Drainage Scenario (described below)** as their baseline condition. In their development of the **CWMP** it was compared and contrasted with the **Existing Condition** and the **Post Drainage Scenario**. Scope and effect modeling was used to estimate acreages of wetlands present in all three; and a wetland functional assessment methodology was used to measure the functional quality of the wetlands present in all three.

The Existing Condition. The existing condition describes the study area at the time the plan was implemented. The ditches are generally assumed to be in poor condition. Based on scope and effect modeling, the 1100-acre parcel contained roughly 690 acres of wetland. It should be noted that this condition may not be static. The amount of wetland may change through time as ditch maintenance and development occur.

The Post-Drainage Scenario. Under this scenario, ditches are assumed to be well maintained as allowed under existing state and Federal exemptions. Using scope and effect modeling, the RCWD predicted about 280 acres of wetlands present in the **Existing Condition** would be drained should ditches be cleaned out. Therefore, under this scenario, the wetlands present in this alternative would be reduced from 690 acres to 410 acres. The modeling predicted that the areas drained would consist of narrow strips of land adjacent to the ditches.

The CWMP. In essence, the goal of the **CWMP** is to have a no net loss of either wetland acreage or wetland functions as compared to the baseline **Post Drainage Scenario.** As with the **Post Drainage Scenario**, it would also contain 410 acres of wetland. However, each landowner would be allowed to reconfigure uplands and wetlands on the site. The goal would be to consolidate the scattered areas modeled as non-wetland in the **Post Drainage** Scenario into one block so they can be utilized by landowners. Wetlands would then be "enhanced' or "created" throughout the balance of the area to assure no loss of wetland functions.

In late summer of 2004, the RCWD requested the St. Paul District use the work done in conjunction with the CWMP to develop a Special Area Management Plan (SAMP) including an expedited permit review process for projects within the CWMP. In evaluating the feasibility of using any plan, including the CWMP, several factors are considered. One of these factors includes verifying the adequacy and accuracy of the technical information used (wetland delineation reports, scope and effect calculations, wetland functional analysis methodologies, etc.) to support the plan or proposal. Another is to determine whether the plan incorporates important features of the laws and regulations we are tasked to implement, for example, the Section 404(b)(1) guidelines.

Scope and effect modeling and wetland functional assessment tools played a significant role in the development of the CWMP. Modeling was used to determine the range and extent of wetlands, and wetland functional assessment tools were used to measure and compare the wetland functions of each alternative. Accordingly, it was critical to independently verify the scientific validity of the analyses, modeling, parameters, and assumptions used.

According to the RCWD a modified van Schilfgaarde equation was used to estimate the scope and effect of ditches; and the Minnesota Routine Assessment Methodology (MnRAM) was used to assess wetland functions (Minnesota Board of Soil and Water Resources 2004).

As the authors understand it, the modified van Schilfgaarde equation was a customization of the van Schilfgaarde equation designed to provide outcomes more consistent with field observations. MVP has limited experience in scope-and-effect modeling. Accordingly, in the fall of 2004 ERDC was requested to review the RCWD modeling. In that review, ERDC suggested that the permeability rates used in the scope-and-effect modeling effort were higher (more rapid) than they would recommend. This recommendation was based on a site visit, literature search, and updated NRCS permeability rates. Subsequent to that review the RCWD submitted a MODFLOW modeling effort to ERDC for review. In a 25 February 2005 memo, ERDC raised several concerns about the MODFLOW model and its ability to simulate monitoring well data.

At the same time the St. Paul District staff was reviewing the MnRAM functional analyses performed by RCWD. MnRAM was created by an interagency team, field tested, and approved for use by the Minnesota Board of Water Resources. District staff were unable to independently verify the results of the

MnRAM analysis, and the results of their analyses were not always consistent with what we would have expected.

In April 2005 the St. Paul District and RCWD decided to clarify how the St. Paul District would use the RCWD scope-and-effect modeling efforts and MnRAM analyses in our review of projects within the CWMP. This agreement would be in the form of a Memorandum of Understanding (MOU). After a series of meetings, the St. Paul District drafted and signed a MOU addressing this issue. The RCWD elected not to countersign the MOU and instead requested language be added to the MOU that would essentially endorse the scope and effect models, wetland functional methodologies, and associated parameters and assumptions used in support of the CWMP.

In response to this request, the St. Paul District requested ERDC's assistance in reviewing the scientific validity of the scope-and-effect modeling, wetland functional assessment methodologies, and associated parameters and assumptions used in these efforts. The attached ERDC report is the result of that request.

2 Scope and Effect of Drainage Ditches

Questions from the St Paul District concerning the scope and effect of drainage ditches on the Village Meadows site primarily relate to two basic issues:

- Are the models used by RCWD appropriate for the site and project, and
- Are the assumptions, inputs, and therefore the results of the models correct?

Modified van Schilfgaarde Equation

RCWD used a modified van Schilfgaarde equation to estimate the scope and effect of the drainage ditches on the Village Meadows site. The modification relates to the variable "depth of the drain" (d). The van Schilfgaarde equation uses the bottom of the ditch as the input variable, but in the Village Meadows site the ditches are partially filled with water at the beginning of the growing season, making the effective depth of the ditch less than the depth of the bottom of the ditch. This modification (using the depth to the water in the ditch in place of the depth to drain (d) in the van Schilfgaarde equation) is appropriate for this setting. The appropriate value for the depth to the drain (d) is described later in this section.

The Army Corps of Engineers (Warne and Woodward 1998) identified the van Schilfgaarde equation as an appropriate method to evaluate the effects of ditches on wetland hydrology from the standpoint of wetland identification and delineation. Woodward and Warne (1997) found that results from the modified van Schilfgaarde equation can make a reasonable prediction of the effects on wetland hydrology caused by ditch construction in areas that do not have extensive surface water ponding. If the input parameters are accurate, the results generally agree with long-term observations and "have proved successful in a variety of landscape settings in different regions of the United States."

The margin of error for the van Schilfgaarde equation (Woodward and Warne 1997) for this site is unknown. Overall margin of error is based on the amount of error in each of the input parameters. As with any equation, a change in input parameters will change the results. ERDC and RCWD disagree on appropriate values of several input parameters. Many of the input parameters used by RCWD in the Village Meadows CWMP scenario (e.g. K, m_0, and d) are based on the results of other models or assumptions.

Hydraulic Conductivity

RCWD used three different approaches to estimate hydraulic conductivity values: one based on the level of decomposition of the organic matter, one based old soil survey estimates, and one based on modeling of well data. The three different methods produced different results. This variability is one of the reasons ERDC recommends the most current Natural Resources Conservation Service (NRCS) soils data as a source of reasonable, readily available, and accessible information on soil properties. ERDC recommends that a hydraulic conductivity value of 0.2 inches per hour (in./hr) be used as the highest hydraulic conductivity for organic soil layers and 6.0 in./hr be used for sandy soil layers on the Village Meadows site. This recommendation is based on the low value in the range of permeability for highly decomposed organic materials and for fine sands from the NRCS Soil Data Base for Anoka County, Minnesota which is available on Soil Data Mart (http://soildatamart.nrcs.usda.gov/). The most current soil data for Anoka

County are available on the Soil Data Mart, which is the official record of soils data for the county. ERDC also recommends that the St. Paul District accept any lower hydraulic conductivity values for these soil materials that RCWD might propose. ERDC recommends 0.2 in./hr for well-decomposed organic materials even though this value is high compared to extensive field studies by Boelter (1965, 1967, 1972, and 1974) and Gafni and Brooks (1990) in Minnesota. Boelter (1972) recorded permeability as low as 0.00052 in./hr in well-decomposed organic soils like those observed on the Village Meadows site.

Height of Water Table

Another variable in the van Schilfgaarde equation on which ERDC disagrees with RCWD is the "initial height of the water table above the center of the drain" (m_o). The initial height of the water table above the center of the drain should reflect a height that represents a water table at the soil surface (0.0 feet below the soil surface). The number entered into the van Schilfgaarde equations located on the NRCS web page (http://www.wli.nrcs.usda.gov/technical/web_tool/Schilfgaarde_java.html) would be 1.3 ft. This is based on data provided by RCWD in file Access_report_dataforms.pdf dated 12/9/2004. Data was provided for 27 wells. Only 3 of the 27 wells (well numbers 11, 20, and 24) did not have a water table at or above the ground surface.

Depth to Drain

Depth to drain (d) in the modified van Schilfgaarde equation used by RCWD is the same as the depth to the water level in the ditch. Water level in the ditch (d) is an important variable to the estimated scope and effect of impact from the drainage ditches at the Village Meadows site. ERDC agrees with 1.3 ft. for the depth of water in the ditches (d) that RCWD apparently used in van Schilfgaarde calculations. RCWD and EOR presented this depth for (d) in a PowerPoint presentation on October 5, 2005 at a meeting with ERDC representatives in Vicksburg, Mississippi.

Water Trapped on Soil Surface

Water trapped at the surface (s) by soil roughness is measured in feet.

According to guidance provided by NRCS, 0.1 ft. would be typical and should be appropriate for the Village Meadows site.

van Schilfgaarde Equation Variables

Table 1 shows the values recommended by ERDC for each of the van Schilfgaarde equation input variables. Values for drainable porosity (f) are weighted averages calculated using the NRCS Map Unit Use Files (MUUF) program, which uses physical soil properties to estimate soil hydraulic properties. The MUUF program is available for download from the National Water and Climate Center (http://www.wcc.nrcs.usda.gov/wetdrain/wetdrain-tools.html). The MUUF program is considered to provide reasonable results for drainable porosity in the absence of laboratory data.

Value for lateral effect distance (Le) is calculated results of the van Schilfgaarde equation. More detailed information about each of the variables can be found in Appendix A.

Table 1 Summary of inputs for Soils Found on the Village Meadows Site Recommended by ERDC for the van Schilfgaarde Equation								
RIFLE								
d (ft)	D (ft)	f	s	m_o (ft)	m (ft)	t (days)	K (in/hr)	Le (ft)
1.3	10	0.117	0.1	1.3	0.3	8	0.2	15
MARKEY								
1.3	10	0.107	0.1	1.3	0.3	8	3.0	72
ISANTI								
1.3	10	0.123	0.1	1.3	0.3	8	6.0	96.5
LINO								
1.3	10	0.16	0.1	1.3	0.3	8	6.0	85
SODERVILLE								
1.3	10	0.18	0.1	1.3	0.3	8	6.0	80
ZIMMERMAN								
1.3	10	0.177	0.1	1.3	0.3	8	6.0	80.5

MODFLOW and XPSWMM

RCWD has proposed that MODFLOW, a more complex groundwater flow model developed by the U. S Geological Survey, would be more appropriate for evaluating the impacts of ditches on the Village Meadows site than the van Schilfgaarde equation. MODFLOW may do a better job of predicting the long-term impacts of the ditches, but does not address the immediate question of the impact of the ditch water elevation to the soil immediately adjacent to the ditch and the change in wetland hydrology in the same way as the van Schilfgaarde equation. In a memorandum to the St. Paul District, Cary Talbot of ERDC described the use of MODFLOW and the results presented by RCWD for the Village Meadows CWMP. In the memo Talbot described concerns about inconsistencies in some of the input parameters used by RCWD and the lack of documentation of how these parameters were determined.

XPSWMM is primarily a dynamic, unsteady flow modeling code used to simulate flow in pipes, channels, and other complex hydraulic environments. The code, as used in this application, also has the ability to account for surface water entering the ditch from overland flow by means of a TR-20-based hydrologic model that is coupled to the hydraulic ditch water-flow model. The study area was divided into sub-basins 10-30 acres in size delineated from available 2-ft topological data. Rainfall runoff was estimated based on the TR-20 method wherein empirical parameters are assigned to each sub-basin based on topography, soil type and vegetative cover. These parameters are curve number (CN), initial abstraction (IA) and time of concentration (TC). After expanding the original model, EOR recalibrated the model by adjusting these parameters to match the recorded response of the system to a 2-in. precipitation event in a 24-hr period. XPSWMM does not provide the capability to simulate subsurface flow. However, groundwater inflow to the ditch system was accounted for in this model by the addition of base flow to the ditch system at unspecified locations as a point source. The base flow amounts were estimated from measurements of low flow conditions in the ditches.

Assumptions about ditch water elevations used in the modified van Schilfgaarde equation and MODFLOW model by RCWD were based on the results of an XPSWMM model that was originally developed by a third party for the city of Blaine, MN. After expanding the model to include a larger portion of the 53 to 62-ditch system, the model was calibrated and evaluated by EOR in December 2002 and deemed to be acceptable for predicting flood elevations and flow rates in the 53 to 62-drainage system for the 100-year precipitation event.

It was not possible to evaluate the appropriateness of the hydraulic and hydrologic parameters, base flow amounts, and point source locations used in the XPSWMM model because the analysis was obtained from direct communication with EOR and a written report of the XPSWMM model application and calibration apparently does not exist. In general, the use of XPSWMM with the TR-20 hydrologic runoff simulation is a reasonable approach to simulate the hydraulic ditch water flow and associated overland flow contribution. However, without knowing the values of the hydraulic parameters (primarily Manning's "n") and the hydrologic parameters CN, IA, and TC used in these calculations, it is not possible to determine if the model was used appropriately. ERDC does not know if the calibration process resulted in a good match between model predictions and actual ditch water elevations for the particular calibration event but due to the non-uniqueness of models, it is possible to reproduce observed conditions with a physically inappropriate parameterization. This is particularly true of empirical, lumped parameter models such as TR-20.

The treatment of the groundwater contributions to the ditch water elevations in the XPSWMM model is another source of concern. A basic premise of the scope and effect calculations is that with lowered ditch water elevations resulting from properly maintained ditches, water that was formerly being stored in the study area soils would be drained, resulting in lowered groundwater levels and thus a lower total acreage of wetlands across the study area. The concern arises from the fact that the volume of drained water is not accounted for in the applicants' method. XPSWMM predicts the lower ditch water elevations in the repaired condition using a pre-repair base flow estimate of groundwater inflow to the ditch at "a few" unspecified locations (based on conversations with EOR). The post-repair lower ditch water elevations then induce increased drainage of groundwater from the study area soils with the ditches being the mechanism for conveying that drained water away from the site. However, the XPSWMM model was not re-run with increased groundwater inflow estimates to reflect the draining condition.

As the ditch water elevations rise due to the increased groundwater inflow, the amount of drainage induced from the wetlands should decrease. Given the exceptionally flat gradient in the study area, the time required to convey the volume of water from the increased drainage out of the system may be significant, thus raising the ditch water elevations for a non-negligible period of time. Iteration between the XPSWMM model and van Schilfgaarde method could help address what effect the increased drainage will have on ditch water elevations and whether this effect is merely transitory or more lasting.

Groundwater

One question that has not been adequately addressed by the RCWD is the input and effects of groundwater on the site. If there is a significant upwelling or upward gradient of groundwater to the site during the early part of the growing season (late April and May), the ditch maintenance may do little to remove wetland hydrology from the site.

In a 2005 report, Verry states (Verry 2005, p. 9 section titled "Well data, hydrograph shape"):

> The well traces (measured and computed) provided by Dr. Djerrari provide some insight to the source water at the various well locations. Wells, 1, 3, 4some, 7, 8, 9, and 10 show extended hydrograph peaks in mid to late May, and again in late June to mid July. This flattening of the hydrograph peaks suggests significant groundwater inflow to the peatland. Both of these flat peak areas may be delayed snowmelt response, the first instance from near by sand uplands, and

> the second instance from uplands farther away. The nearby areas may be immediately adjacent to the Rehbein peatlands (e.g. a 1/2 mile or so), while the farther away areas may be 4 to 5 miles away.
>
> This delayed groundwater input is typical of fen peatlands. At our Marcell Experimental Forest, the second input wave also occurs from late June through mid July from a subcontinental divide area (Mississippi and Hudson Bay) five miles north of a black spruce fen. I don't know how the MODFLOW process might handle these inputs, but they are common. This process may explain why the modeled response curves drop faster than the observed hydrographs at the hydrograph peaks.

The van Schilfgaarde equation does not account for possible upwelling of groundwater in the study area, so this method cannot simulate the scope and effects of ditch maintenance if indeed there is "significant groundwater inflow to the peatland" as Dr. Verry suggests.

Conclusions and Recommendations Regarding Drainage Ditches

The question of whether wetland hydrology can be removed from the soils at the Village Meadows site needs to be addressed in terms of the primary source of water that will be drained from the site as a result of the ditch maintenance. If this water is primarily trapped water due to infiltration of precipitation that simply does not have a means to drain or be evapotranspired within the time frame of interest, then the answer to this question is likely "yes." If maintained as proposed, the ditches can be expected to remove wetland hydrology from a portion of the site, but for a smaller acreage than that stated by RCWD. However, if a major source of water to the Village Meadows site is the upwelling and discharge of groundwater, the potential effects of ditches on wetland hydrology are more complex and cannot easily be evaluated except through direct hydrologic monitoring or sophisticated modeling, perhaps in combination.

The validity of the ditch water elevations as computed by the XPSWMM model remains an unanswered question due to the inability to verify the parameters used in the model and a lack of available calibration performance over critical portions of the hydrologic cycle. Comparing model results with observed field data over a variety of storm events in the different seasonal periods encountered in the RCWD study area would provide a means of validating the XPSWMM model-derived ditch water elevation assumptions. Until these models can be verified and validated, ERDC cannot recommend that the results of the XPSWMM and MODFLOW models be used for the CWMP.

Interpreting the well data provided by EOR to estimate hydraulic conductivity on this site is problematic. No information was provided about how the wells were constructed, installed, or maintained. For this reason ERDC does not recommend that the well data provided by EOR be used for hydraulic conductivity determinations. However, in the future if applicants for similar projects want to directly measure the impacts of existing ditches on the hydrology for wetland identification or delineation purposes, ERDC recommends that a transect of shallow water table wells be installed in a transect perpendicular to the ditch according to the Army Corps of Engineers technical standard (U.S. Army Corps of Engineers 2005). *Water Table Monitoring Project Design* (Noble 2006) provides guidance on the number and placement of wells. The spacing between wells should be 25 to 50 ft. ERDC recommends that wells be monitored daily during the period of the growing season when water tables are highest (typically late April and May in Minnesota). Depth to water in open ditches should be measured at the same time during the same period as the water table wells.

In attempting to assess the effects of modifications to wetland hydrology, such as those proposed in this application, it is important to use a tool with a level of sophistication and complexity that is appropriate to the level of detail needed for the study. Simple analytical methods (e.g., the van Schilfgaarde equation) are appropriate for simple systems that also have minimal potential adverse impacts. However, as the level of complexity of the wetland and subsurface hydrologic systems increases, and the size, sensitivity, and/or relative importance of the wetland increase, more sophisticated tools are required, particularly when simpler tools are shown to be inadequate. In the case of RCWD, the recognition by the applicant that the van Schilfgaarde equation was not detailed enough to "provide a reasonable estimate of post-drainage conditions" led to a decision to use "a more sophisticated model" to assess the impacts for a portion of the study area. The applicant's choice to use MODFLOW in conjunction with the surface water model XPSWMM, is a step in the right direction of increased sophistication. However, as noted previously, there are limitations inherent in the use of MODFLOW/XPSWMM for this type of a system.

Tools are presently available to the USACE that are fully capable of addressing the lateral drainage effects of a system such as this in cases where the need for sophistication, accuracy, and detail are paramount. This is the class of tools that should be used in addressing questions of drainage effects on the Village Meadows site. The Gridded Surface-Subsurface Hydrologic Analysis (GSSHA) model supported in the Watershed Modeling System (WMS) and the Adaptive Hydraulic and Hydrologic (ADH) model supported in the Groundwater Modeling System (GMS) are two examples of tools available to the USACE and world-wide engineering communities that currently represent the highest levels of sophistication in simulating the interaction between surface and subsurface hydrologic systems. The decision of when to use the highest level of sophistication versus more simplistic approaches is one that must be made after considering all relevant technical and other issues by the appropriate regulatory authority.

3 Functional Analysis

MnRAM

MnRAM was used to compare wetland functions between alternative land use scenarios. However, RCWD did not use MnRAM as described in the Comprehensive General Guidance dated July 14, 2004 to make a functional analysis of Village Meadows CWMP. Overall, the method used by RCWD bears little resemblance to MnRAM.

MnRAM is a method that assesses wetland functions and values through a series of questions that are answered by those making the assessment while in the field looking at the wetland. A data sheet is included with the MnRAM documentation. There was considerable confusion regarding the questions used by RCWD. The reason for the confusion was that RCWD used different terminology and descriptions for questions than are found in MnRAM documentation. Table B1 in Appendix B describes the headers used in the RCWD database and the correlation to MnRAM questions. MnRAM requires experience and training in wetland science to be properly applied. MnRAM documentation states that certain questions can potentially be answered using Geographic Information System (GIS) and identifies those questions appropriate for this type of analysis. RCWD chose to ignore many of the questions identified in MnRAM as appropriate for GIS analysis.

Of the 72 questions used in MnRAM, RCWD used only 17 questions to assess the wetlands for the Village Meadows CWMP. Only MnRAM questions 13, 14, 15, 18, 20, 23, 26, 28, 38-44, 46, and a vegetative quality question were answered (Table 2). Of these questions, 13, 14, 15, 18, 20, 23, 26, 28, 38, 39, 41, 42, 43, 44, and 46, as well as the vegetative quality question were answered based on GIS data rather than onsite field observations as specified in MnRAM 3.0. MnRAM identifies questions 64 through 72 as optional and not necessary for use of the method. Some additional questions can reasonably be deleted from this analysis, such as those that only relate to open water (e.g., question 33, Shoreline erosion potential). Other questions are not directly used to assess functions (e.g., question 47, "fish species list") and can be deleted. However, the reasoning behind the deletion of these and other questions should have been documented in the report. It was explained to ERDC during the RCWD meeting in Vicksburg, Mississippi on October 5, 2005 that the modifications eliminated "value" questions to concentrate on questions related to functions. Supposedly these changes were made with the knowledge of a working committee, including the St. Paul District, but no documentation could be found that the federal, state, or local agencies involved agreed with these changes. No documentation was provided to explain specifically what changes were made or why they were made so ERDC was not able to evaluate the logic of the changes.

MnRAM documentation clearly states that "Wetland Assessments using this methodology cannot be conducted without a site visit." EOR, in a memo ("MnRAM 3.0 Existing Conditions Protocol use in RCWD CWMPs") dated August 13, 2004, identified several questions that were answered using GIS that were not identified as appropriate for GIS analysis in the MnRAM documentation. It is also unclear how many questions were answered or were verified in the field because none of the original data sheets were submitted for this review. Quality control on the data collection is also considered to be suspect, as indicated by the fact that some of the assessed areas are listed as having zero acres (0.000 acres). How were these areas located in the field for an onsite assessment?

Table 2
MnRAM – Rice Creek Comparison Table

MnRAM Question #	MnRAM Question Description	RC Description	Functions							
4	Rare plants									
5										
6										
10										
12	Outlet characteristics for flood retention									
13	Outlet characteristics for hydrologic regime	OUTLET	A	B	C		E			
14	Dominant upland land use (within 500 ft)	IMPERVIOUS	A	B	C			F		L
15	Soil condition (wetland)	SOILINTG	A	B						
16	Vegetation (% cover)									
17	Emerg. veg. flood resistance									
18	Sediment delivery	SEDIMENT		B	C	D		F	G	
19	Upland soils (based on soil group)									
20	Stormwater runoff pretreatment & detention	POLL_DISCH	A	B	C	D	E	F	G	
21	Subwatershed wetland density									
22	Channels/sheet flow									
23	Upland naturalized buffer average width (ft)	WQBUFF/ WLBUFF			C	D	E	F	G	L
24	Upland Area Management:									
25	Upland Area Diversity & Structure:									
26	Upland Area Slope:	UPLBUFF			C	D			G	
27	Downstream sensitivity/WQ protection									
28	Nutrient loading	NUTRIENT				D		F	G	
29	Shoreline wetland?	N/A								
30	Rooted shoreline vegetation (%cover)	N/A								
31	Wetland in-water width (in ft, average)	N/A								
32	Emergent vegetation erosion resistance	N/A								
33	Shoreline erosion potential	N/A								
34	Bank protection/upslope veg.	N/A								
35	Rare Wildlife									
36	Scarce/Rare/S1/S2 local community									
37	Vegetation interspersion cover (diagram 1)									
38	Community interspersion (diagram 2)	INT_INTER					E			L
39	Wetland detritus	LITTER					E			
40	Wetland interspersion on landscape	INTEPER					E			
41	Wildlife barriers	FRAGMENT					E			L
42	Amphibian breeding potential-hydroperiod	BREED_POT						F		
43	Amphibian breeding potential-fish presence	PRED_FISH						F		
44	Amphibian & reptile overwintering habitat	OVERWINT						F		
45	Wildlife species (list)	Data not used								
46	Fish habitat quality	SPAWNING							G	
47	Fish species (list)	Data not used								
48	Unique/rare educ./cultural/rec.opportunity									
49	Wetland visibility									
50	Proximity to population									
51	Public ownership									
52	Public access									
53	Human influence on wetland									
54	Human influence on viewshed									
55	Spatial buffer									
56	Recreational activity potential									
57	Commercial crop--hydrologic impact									
58	GW - Wetland soils									
59	GW - Subwatershed land use									
60	GW - Wetland size and soil group									
61	GW - Wetland hydroperiod									
62	GW - Inlet/Outlet configuration									
63	GW - Surrounding upland topographic relief									
64	Restoration potential w/o flooding									
65	Landowners affected by restoration									
66	Wetland size									
67	Average width of naturalized upland buffer (potential)									
68	Ease of potential restoration									
69	Hydrologic alteration type									
70	Potential wetland type (Circ. 39)									
71	Wetland sensitivity to stormwater									
72	Additional stormwater treatment needs									
99	Natural Heritage Program Veg. Com. Ranking				C	D			G	

Of the eight functions assessed by RCWD, only the hydrology function questions and formula were employed in a manner consistent with MnRAM guidance. All other methods used by RCWD deviated from MnRAM specifications. MnRAM uses models or equations that combine the questions in a way that gives greater weight to certain questions in determining the functional rating for each function. RCWD chose instead to use a sum of the questions selected for all functions. This approach gives a very different result that cannot be compared to the results from MnRAM for the same site. The models used by RCWD for each function can be found in Table 3.

Table 3
Models or Equations Used by RCWD to Describe Function for CWMP

Function		Model or equation
A	HYDROLOGY	(IMP_CAL+ OUT_CAL+ SOLINT_CAL+ POLDIS_CAL)/4
B	FLOOD	(IMP_CAL+ OUT_CAL+ SOLINT_CAL+SED_CAL+POLDIS_CAL)/5
C	WATER QUALITY (downstream)	(IMP_CAL+ OUT_CAL+ SED_CAL+ POLDIS_CAL+ WLBUFF_CAL+ ULBUFF_CAL+ VEG_CAL)/7
D	WATER QUALITY (wetland)	(SED_CAL+ POLDIS_CAL+ WQBUFF_CAL+ ULBUFF_CAL+ NUT_CAL+ VEG_CAL)/6
E	WILDLIFE HABITAT	(OUT_CAL+ POLDIS_CAL+ WLBUFF_CAL+ LIT_CAL+ INTSPR_CAL+ FRA_CAL + VEG_CAL+ INT_INTER+ RARE)/9
F	AMPHIBIAN HABITAT	(IMP_CAL+ SED_CAL + POLDIS_CAL+ WLBUFF_CAL+ NUT_CAL+ BREED_POT + PRDFSH_CAL+ OVRWNT_CAL+ VEG_QUAL)/9
G	FISH HABITAT	(SED_CAL+ POLDIS_CAL + WQBUFF_CAL+ ULBUFF_CAL+ NUT_CAL+ VEG_CAL+ SPN_CAL)/7
L	LANDSCAPE	(IMP_CAL+ WLBUFF_CAL+ WQBUFF_CAL+ INTSPR_CAL+ FRA_CAL+ SPECIAL)/6
	FUNC_SUM	A+B+C+D+E+F+G

Unfortunately, it is not possible to compare the results of the RCWD modified analysis with a true MnRAM analysis, since both methods were not performed on a range of selected sites within the CWMP.

The St. Paul District specifically asked ERDC to identify and confirm which MnRAM 3.0 questions and formulas were used to generate the data displayed under selected column headings of the database provided by RCWD: A through G; FUNC_SUM; FUNCSUMxAC; Arel_ac to VEGrel_ac; and A_REL to VEG_REL.

Table 3 identifies the questions used by RCWD to generate the values under column heads A through L, each of which represents a particular function. The result for each function was an average of the scores for the individual questions selected by RCWD as contributing factors for that function. The equations provided by EOR can be found in Table 3. This simple average approach is a deviation from MnRAM 3.0 other than for function A - Maintenance of Characteristic Hydrologic Regime.

Based on the information provided by RCWD (Table 3), FUNC_SUM is a total of the scores for functions A – G, but does not include function L. Table 3, which reports summary data of scores from multiple wetland types, incorporates a total score across all functions that appears to be the same concept as FUNC_SUM, but includes a function "V" that was not included in the FUNC_SUM equation presented in Table 3. FUNC_SUM is not described or used in MnRAM 3.0.

FUNCSUMxAC is the result of summing A – G multiplied by the acres, to generate a measure of functional units equivalent to the FCUs reported in Table 4. Thirty-one polygons are identified that have 0.000 acres in the post_mnram and cwmp_mnram assessments. The presence of an assessment on a site with no area raises a question of how these places were assessed.

A_REL to G_REL are the average of the scores for each of the functions (A to G) divided by the number of questions that RCWD applied to a particular function, this is similar to the Functional Index Score used in MnRAM 3.0, but differs greatly in how the result is derived. Table 2 identifies the number of questions used for each function. It appears that VEG_REL is a stand-alone function and is not combined with other questions.

Arel_ac to VEGrel_ac is the Functional Index Score for each function (A-REL to VEG_REL) multiplied by the acres for that polygon to give Functional Capacity Units (Smith et al. 1995). Functional Capacity Units are not described in MnRAM 3.0

Reviewing the assessment data, ERDC found that calculations were correct, except that FUNC_SUM does not correctly total the functions A – G. Apparently VEG_CAL was included in FUNC_SUM as a stand-alone function. This deviates from the data that were received on October 18 from Jason Naber (Naber 2005). In those data, only functions A – G were used to calculate FUNC_SUM. ERDC has not found where the Landscape function was used.

Conclusions and Recommendations Regarding Functional Analysis

The method employed by RCWD to conduct the functional analysis of CWMP deviated significantly from the Minnesota Routine Assessment Method for Evaluating Wetland Functions 3.0 (MnRAM as described in the Comprehensive General Guidance dated July 14, 2004). Because of the modifications to MnRAM it was not possible to determine if results were logical, accurate, or how they deviated from a true MnRAM functional analysis.

In general terms the best case scenario is presented in the CWMP. The CWMP plan basically states that if impacts to the site occur as predicted after drainage, much of the site would receive a low score for most functions. With the restoration plan in place, most of these sites would go from a low functional score to a high functional score. The difference in scores between drained condition and restored condition are exaggerated by a method that gives a site with a low score a value of 0.0 and a high score a value of 1.0. This disparity of 0.0 to 1.0 is usually not found in real-world conditions. A possible alternative scenario is that the drained condition had less impact than predicted (see scope and effect discussion above) by RCWD. In this case, many areas that are given a score of 0.0 could remain in their current functional condition and receive a functional score of medium or 0.5. Restoration of wetlands is not a certainty. Many restoration projects fail or meet with less than the predicted high levels of success. If the restoration efforts outlined in the CWMP meet with less than predicted results, then the functional score might be medium rather than high. If the initial functional score is medium and the restored functional score is medium, then there would be no increase in functional score. Another possible alternative would be that the restoration efforts failed completely and resulted in a functional score lower than medium or the current condition. An important assumption is that all wetland functions can be restored to all wetland types. This is often not the case. Some wetland types are easier to restore than other wetland types. Some wetland functions are easier to restore than other wetland functions. RCWD assumes a high level of function immediately following restoration. This is never the case. There is always a lag in achieving a high level of function, if a high level of function is even attainable. The loss of function during the lag should also be mitigated. An example should be presented and documented to support this conclusion. The example should illustrate the high level of functional capacity that RCWD describes immediately after restoration at a highly impacted and disturbed site with soils and hydrology similar to the site under investigation.

Table 4 represents the best case scenario currently presented in CWMP. The worst case scenario would be represented by no increase in functional units after restoration.

Table 4
Functional Capacity Units by Wetland Type and Function Compiled by ERDC (based on predicted RCWD data)

		Predicted Post Drainage Alterative							Predicted Restored Alterative (CWMP)							Total increase in FCUs by function	% increase in FCUs by function
		Wetland Types							Wetland Types								
	Functions	**1**	**2**	**3**	**4**	**6**	**7**	**TOTAL**	**1**	**2**	**3**	**4**	**6**	**7**	**TOTAL**		
A	HYDROLOGY	8	64	5	2	21	14	114	11	87	48	5	62	29	242	128	112
B	FLOOD	9	77	5	2	23	16	132	10	91	52	4	61	30	248	116	88
C	WATER QUALITY (downstream)	9	67	7	3	24	15	125	10	114	69	6	68	35	302	177	142
D	WATER QUALITY (wetland)	14	111	8	4	32	22	191	13	143	88	7	86	44	381	190	99
E	WILDLIFE HABITAT	12	98	8	4	30	23	175	11	121	74	6	77	41	330	155	89
F	AMPHIBIAN HABITAT	11	67	8	4	29	28	137	11	99	69	7	68	35	289	152	111
G	FISH HABITAT	11	90	8	3	29	28	159	12	127	78	6	77	40	340	181	114
V	VEG DIVERSITY/INTEGRITY	3	23	5	1	22	5	59	13	149	93	5	90	46	396	337	571
	Total	77	597	54	23	210	131	1092	91	931	571	46	589	300	2528		
									77	597	54	23	210	131			
	Total amount of increase in FCUs by wetland type								**14**	**334**	**517**	**23**	**379**	**169**			
	% increase of FCUs by wetland type								18	56	957	100	180	129			

The following list suggests possible improvements to the MnRAM 3.0 assessment method and an alternative to its use:

- MnRAM should be completed for the CWMP using the protocol and data sheets provided in the Minnesota Routine Assessment Method version 3.0 documentation. An assessment team should consist of an interdisciplinary, interagency group of wetland scientists including representatives of the Corps and RCWD.
- There is currently too little distinction between predicted function levels in MnRAM (high/medium/low). Usually with this type of broad categories most sites are assessed as medium.
- Lack of measured data for variables leads to differences of opinion between experts and no way to resolve them.
- The St. Paul District may want to consider the development of a Hydrogeomorphic Model (HGM) for these types of wetlands if more wetlands, similar to the Village Meadows site, are likely to be impacted in the future. HGM is a rapid, reference-based wetland functional assessment that could provide a higher degree of resolution than MnRAM.

In addition to the deficiencies in the wetland functional assessment, a wide array of potential problems exists in the restoration plan proposed by RCWD. This list might include, but is not limited to, the following:

- If organic soil material is stockpiled, after excavation and before being used for backfill it can oxidize and potentially reduce in volume.
- If the soils become dry while stockpiled they are subject to blowing by the wind, which can further reduce the soil volume.
- Sands can cave into the excavated area and partially fill the area.
- Organic soils near the dewatered area will oxidize and reduce in volume.
- The reestablishment and maintenance of wetland hydrology may not occur as predicted and must be monitored to verify that wetland hydrology has been established and is being maintained.
- The reestablishment and maintenance of native wetland vegetation may not occur as predicted and must be monitored to ensure that wetland vegetation has been established.

However, these potential problems could at least be reduced with proper planning, construction, monitoring, and maintenance.

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Appendix A

Input parameters for the van Schilfgaarde equation are discussed below in greater detail than in the main text:

K = hydraulic conductivity

Soil permeability or hydraulic conductivity is one of the most significant values used in scope and effect equations. The scope and effect equation is used in this instance to evaluate the potential effectiveness of drainage ditches within the Rice Creek Drainage District. For practical purposes, soil permeability and hydraulic conductivity have the same definition with regard to scope and effect of drainage ditches. After looking at the soils onsite and reviewing Dr. David Grigals' memo dated July 9, 2003 and references by Boelter (1965, 1967, 1972, 1974) and Gafni and Brooks (1990), the author recommends the use of the low value in the range of permeability from the Natural Resources Conservation Service (NRCS) Soil Data Base for Anoka County, Minnesota. The database is available on Soil Data Mart (http://soildatamart.nrcs.usda.gov/). Data available on the Soil Data Mart are the most current soil data and are the official record of soils data for Anoka County.

The ranges in permeability found in the Anoka County, Minnesota Data Set are estimates based on the range of soil textures identified for a soil series. For example, the soil texture Rifle is "mucky peat," which is moderately decomposed organic material (USDA Soil Conservation Service 1993, USDA 1999). During a site visit on August 24, 2004, the author identified the organic materials on the Rice Creek site to be muck, which is well decomposed organic material, based on the low fiber content (less than one-sixth of the volume). Boelter (1965, 1967, 1972, and 1974) found that well decomposed organic materials (muck) can have permeability less than 0.00052 in/hr. Using a different method of measurement, Gafni and Brooks (1990) achieved similar results for organic soils in Minnesota. Therefore, the lowest values for the range of soil permeability found in the soil data set for Anoka County could be assumed to adequately represent the soils found within the RCWD.

In a report provided by RCWD, Verry (2005) used the von Post method to determine the degree of decomposition of organic soil materials at selected locations within the RCWD. This is a recognized field method for determining organic decomposition (ASTM D 5715-00, 2000). However, in contradiction to Verry who stated in his January 2, 2005 report that sapric peats are defined by von Post groups H8 through H10, the ASTM standard defines groups H7 through H10 as sapric (the most decomposed group) as defined by NRCS. Certainly a well defined and thoroughly conducted onsite sampling of the degree of soil decomposition is preferred over a small amount of data. The author does not believe that the characterization of only 11 sample sites reported in the EOR documentation adequately characterizes organic soils on the site. The author also questions the usefulness of the sample locations as representative of the site and assumed disturbance. Based on the well data provided by EOR, most of the well sites were wet during the period of monitoring, at least during the early part of the growing season (in some cases the entire growing season) indicating the much of the site had wetland hydrology. The wetness of the soils near the wells should reduce decomposition of organic materials and these soils will be less decomposed than the soils near the ditches. This assumes that the ditches currently have any impact on the water table. During a site visit in August 2004, the author concentrated on soils that would be most impacted (within 100 ft or less of the ditch). This difference in site observations might account for the discrepancy between the author's conclusion that the soils are sapric throughout the site and those of Verry who reports that soils ranged from H3 (very slightly decomposed peat) to H9 (muck).

The same principles apply to the underlying sandy material, found under the organic material at some sites. The estimated range of soil permeability found in the Soil Survey Data Set represents the range of textures found for a particular soil series. At all sites where sand was encountered under the organic materials during the author's site visit, fine sands were identified. Fine and very fine sand textures were also identified by Verry (2005). Fine sands represent the low end of the range of soil permeability for those soil layers.

D = equivalent depth from drainage feature to impermeable layer 10 ft is the recommended value for this variable and is appropriate for the RCWD site.

m = height of water table above the center of the drain at midplane after time (t) 0.3 ft would be the appropriate value for a wetland impact evaluation such as the RCWD site.

$\mathbf{m_0}$ = initial height of water table above the center of the drain at t

The initial height of the water table above the center of the drain should reflect a height that represents a water table at the soil surface (0.0 ft below the surface). The number entered into the van Schilfgaarde equations located on the NRCS web page (http://www.wli.nrcs.usda.gov/technical/web_tool/Schilfgaarde_java.html) would be 1.3 ft. This is based on data provided by RCWD in file Access_report_dataforms.pdf dated 12/9/2004. Data were provided for 27 wells. Only 3 of the 27 wells (numbers 11, 20, and 24) did not have a water table at or above the ground surface.

If all or portions of the site have surface water, then the van Schilfgaarde equation would not be appropriate for those areas. Kirkham's equation would be more appropriate to determine the removal of the surface water. Kirkham's equation is often combined with the van Schilfgaarde equation to calculate the total impact of surface and soil water removal.

t = time for water table to drop from m_0 to m, days (8 days)

f = drainable porosity of the soil is the volume of water that will be released per unit volume of soil by lowering the water table a unit depth, in this case 12 in.

Drainable porosity is calculated using the NRCS Map Unit Use Files (MUUF) program, which uses soil physical properties to estimate soil hydraulic properties. The MUUF program is available for download from the National Water and Climate Center (http://www.wcc.nrcs.usda.gov/wetdrain/wetdrain-tools.html). The MUUF program is considered to provide reasonable results for drainable porosity in the absence of laboratory data.

Drainable porosities for the following soils calculated from the MUUF program are:

- Rifle muck = 0.1167
- Markey = 0.107
- Isanti = 0.123
- Lino = 0.16
- Soderville fine sand = 0.18
- Soderville loamy fine sand = 0.16
- Zimmerman fine sand = 0.177
- Zimmerman loamy fine sand = 0.1566

Appendix B

Table B1 Description of Headers from EOR Database and Correlation to MnRAM Questions	
Header	**Description**
ID	Unique polygon identification label
FEE_OWNER_	Field listing the legal entity that owns the property (pays the taxes)
CNUMD	MLCCS Level 4 or 5 Land Cover Type - Number Code
M_33X_	Modifiers to indicate natural quality of a site
IMPERVIOUS	MnRAM question #14
IMP_CAL	Quantified calculation for Imperviousness for High, Medium, or Low
FRAMENT	MnRAM question # 41
FRA_CAL	Quantified calculation for Fragmentation for High, Medium, or Low
INTERPER	MnRAM #40: Interspersion
INTSPR_CAL	Quantified calculation for Interspersion for High, Medium, or Low
WLBUFF	MnRAM #23
WLBUFF_CAL	Quantified calculation for Widths for Wildlife Buffers: High, Medium, or Low
WQBUFF	MnRAM #23: Widths for Water Quality
WQBUFF_CAL	Quantified calculation for Widths for Water Quality: High, Medium, or Low
OUTLET	MnRAM question #13. Outlet Characteristics
OUT_CAL	Quantified calculation for Outlet Characteristics: High, Medium, or Low
POLL_DISCH	MnRAM question #20. Pollutant Discharge
POLDIS_CAL	Quantified calculation for Pollutant Discharge: High, Medium, or Low
SEDIMENT	MnRAM question #18. Sediment Delivery
SED_CAL	Quantified calculation for Sediment Delivery: High, Medium, or Low
NUTRIENT	MnRAM question #28. Nutrient Loading
NUT_CAL	Quantified calculation for Nutrient Loading: High, Medium, or Low
LITTER	MnRAM question #39. Litter Condition
LIT_CAL	Quantified calculation for Litter Condition: High, Medium, or Low
SOIL_INTG	MnRAM question #15. Soil Integrity
SOLINT_CAL	Quantified calculation for Soil Integrity: High, Medium, or Low
UPLBUFF	MnRAM question #26. Upland Buffer Slope
ULBUFF_CAL	Quantified calculation for Upland Buffer Slope: High, Medium, or Low
SPAWNING	MnRAM question #46. Adjacent Spawning Habitat
SPN_CAL	Quantified calculation for Adjacent Spawning Habitat: High, Medium, or Low
PRED_FISH	MnRAM question #43. Predatory Fish
PRDFSH_CAL	Quantified calculation for Predatory Fish: High, Medium, or Low
OVERWINT	MnRAM question #44. Overwintering for Amphibians
OVRWNT_CAL	Quantified calculation for Overwintering: High, Medium, or Low
VEG_QUAL	MnRAM question #99 Natural Heritage Program Vegetative Community Ranking
VEG_CAL	Quantified calculation for Vegetative Quality: High, Medium, or Low
BREED_POT	MnRAM question #42. Breeding Potential for Amphibians
A	MNRAM 3.0 Wetland Function A. Maintenance of Characteristic Hydrologic Regime
B	MNRAM 3.0 Wetland Function B. Flood/Stormwater/Attenuation
C	MNRAM 3.0 Wetland Function C. Downstream Water Quality
D	MNRAM 3.0 Wetland Function D. Maintenance of Wetland Water Quality
E	MNRAM 3.0 Wetland Function E. Maintenance of Characteristic Wildlife Habitat Structure
F	MNRAM 3.0 Wetland Function F. Maintenance of Characteristic Amphibian habitat
G	MNRAM 3.0 Wetland Function G. Maintenance of Characteristic Fish Habitat
FUNC_SUM	Functional Sum of MnRAM 3.0 Wetland Functions
ACRES	# Acres contained in individual polygon
FUNCSUMXAC	Functional Sum multiplied by Acreage
LANDSCAPE	MnRAM 3.0 Landscape Level Assessment Calculation
SPECIAL	"Special Features" presence or absense of Special Feature elements for the MnRAM analysis that will have a final impact on wetland functional scoring - but they are not addressed in specific MnRAM question #'s.
RARE	Within the vicinity of a Rare Feature (MnDNR County Biological Survey/Natural Heritage)
INT_INTER	MnRAM question #38.
ITINTR_CAL	Quantified calculation for Vegetative Interspersion Class: High, Medium, or Low
COWD	COWARDIN: Cowardin Wetland Classification Code - Alpha Code
AREA	Square Meters

PERIMETER	Perimeter of Polygon
DESCRIPTIO	Full text description of the MLCCS classification code
NATIVE	Native Community to Minnesota or not
COWARDIN	Cowardin Wetland Classification Code - Alpha Code
MAJOR_TYPE	Major Wetland Type
SUSCEPT_CL	Stormwater Susceptibility Class
AFFECTED	Affected by ditch or not
CNUMD_12	Old version of MLCCS Level 4 or 5 Land Cover Type - Number Code
WPZIN	Within Wetland Preservation Zone or not
WPZOUT	Within Wetland Preservation Zone or not
WET_EXIST	Circular 39 Wetland Classification Code - Numeric Code for Existing Conditions
WET_POST	Circular 39 Wetland Classification Code - Numeric Code for Post Drainage Scenario
WET_CWMP	Circular 39 Wetland Classification Code - Numeric Code for CWMP
NON_WET	Wetland or Non wetland under CWMP
A_REL	Relativized Score of Wetland Function A. Maintenance of Characteristic Hydrologic Regime
B_REL	Relativized Score of Wetland Function B. Flood/Stormwater/Attenuation
C_REL	Relativized Score of Wetland Function C. Downstream Water Quality
D_REL	Relativized Score of Wetland Function D. Maintenance of Wetland Water Quality
E_REL	Relativized Score of Wetland Function E. Maintenance of Characteristic Wildlife Habitat Structure
F_REL	Relativized Score of Wetland Function F. Maintenance of Characteristic Amphibian habitat
G_REL	Relativized Score of Wetland Function G. Maintenance of Characteristic Fish Habitat
VEG_REL	Relativized Score of Vegetative Quality